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Corrosion-erosion Resistant Processing Method by Cavitation on Metal Workpiece Surface, Method of Decreasing Cavitation Erosion and Product Processed to Improve Corrosion-erosion Resistance and Cavitaion-erosion Protection Performance
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SOYAMA, Hitoshi, et al.

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INVENTOR(S)	(72):	SOYAMA, Hitoshi; SATO, Takeshi; and SAKA, Masumi
APPLICANT(S)	(71):	SOYAMA, Hitoshi
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[What is Claimed is:]

[Claim 1]

A method of corrosion resistant processing a workpiece and/or method of decreasing cavitation erosion on said workpiece, characterized in that, when cavitation bubbles are generated in liquid by using liquid jet or ultrasonic vibrations and collide with a surface of a workpiece and crush, the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

[Claim 2]

A method of corrosion-erosion resistant processing a workpiece and/or method of decreasing cavitation erosion on said workpiece, characterized in that cavitation bubbles are generated in alkaline liquid by using liquid jet or ultrasonic vibrations, said cavitation bubbles collide with a surface of a workpiece and crush and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

[1] Numbers in the margin display pagination in the foreign text.

[Claim 3]

A method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, characterized in that a cavitation processing container containing alkaline liquid is placed on a workpiece, liquid is poured into said container so as to pressurize the inside of said container, pressurizing liquid for generating cavitation bubbles is injected to said pressurized container so as to increase the crushing impact strength of said cavitation bubbles and the electric potential of the surface of said workpiece is increased thereby forming a passive layer on the surface of said workpiece.

[Claim 4]

A method of corrosion-erosion resistant processing of a fluid apparatus and/or a method of decreasing cavitation erosion on said device, characterized in that, when said fluid apparatus has a structure wherein cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations, and a structure wherein said generated cavitation bubbles collide and crush, alkaline liquid is used as said liquid or liquid made by adding an alkaline agent to said liquid is used.

[Claim 5]

The method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece,

as set forth in claim 1, 2, 3 or 4, characterized in that said cavitation erosion means both cavitation corrosion and/or cavitation erosion.

[Claim 6]

The method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, as set forth in claim 1, 2, 3 or 4, characterized in that said workpiece is made from a material selected from a group made from carbon steel, ferrite group low-alloy steel, iron group cast metal, stainless steel, aluminum and aluminum alloy.

[Claim 7]

A product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance, characterized in that, when cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations and collide with a surface of a workpiece and crush, the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

[Claim 8]

A product processed to improve corrosion-erosion resistance and/or cavitaion-erosion protection performance, characterized in that, when cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations and said cavitation bubbles collide with

a surface of a workpiece and crush, property modification of the surface of said workpiece, which includes hardening of the surface, improvement of the compressive residual stress and the fatigue stress on the surface, is made by using the peening effect of the crushing impact strength, or when said workpiece is washed by using the crushing impact strength, the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased thereby generating a passive layer on the surface of said workpiece.

[Claim 9]

The product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance, as set forth in claim 7 or 8, characterized in that examples of said workpiece include processed products and machine components, which are made from a material selected from a group made from carbon steel, ferrite group low-alloy steel, iron group casting metal, stainless steel, aluminum and aluminum alloy.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a method of corrosion-erosion resistant processing of a workpiece such as machine components and fluid apparatuses, which are made from a material selected from a

group made from carbon steel, ferrite group low-alloy steel, iron group casting metal, stainless steel, aluminum and aluminum alloy, or a method of decreasing cavitation erosion on said workpiece. The present invention also relates to a product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance.

[0002]

[Prior Arts]

Conventionally, by using the peening effect of high-speed submerged liquid jet, which generates cavitation, property modification of the surface of metal components, which includes hardening of the surface, improvement of the compressive residual stress and the fatigue stress on the surface, is made (see Japanese unexamined published applications Nos. Sho 59-193215 and Hei 4-240073). Here, the above described surface property modification is exclusively made by the mechanical effect of the crushing impact strength of air bubbles. Since application of the compressive residual stress is also effective against the stress corrosion cracking, an expression of decreasing corrosion is sometimes used. However, in these prior arts, corrosion, which is a chemical effect, is prevented by the mechanical effect of the crushing impact strength of air bubbles.

[0003]

A recent prior art (see Japanese unexamined published application No. Hei 7-328859) discloses a corrosion-erosion resistant processing method by cavitation wherein a product is collided with cavitation by a liquid jet in liquid. This prior art writes: "When cavitation bubbles are rapidly crushing, oxygen in liquid is contained in the air bubbles and transported to the surface of the product. This transportation is repeated the same number of times as that of the crushing times of the air bubble and iron (Fe) functions as a catalyst thereby forming a stable passive layer.

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As a result, the surface of the product is electrochemically highly stable, which stops advancement of corrosion. To stably form said passive layer, the optimum state of the liquid jet or cavitation is necessary. For example, when a submerged water jet is used, if the crushing impact strength against the product is excessive, erosion is generated on the product, ultrafine pieces, which are separated from the product, strongly rub the surface of the product thereby peeling off the passive layer.". The description of the prior art suggests that a passive layer may be formed due to rapid crushing of the cavitation bubbles. However, it does not clarify why the above described passive layer is formed and how the above described passive layer can be stably formed. Furthermore, since injecting cavitation bubbles may promote the corrosion, the description of the

specification of the above described prior art is not correct. However, the above described prior art has a significance in finding that there is a possibility that rapid crushing of cavitation bubbles may form a passive layer. However, this prior art fails to point out the major factor of the phenomenon wherein the passive layer is formed and cannot continuously reproduce nor put this phenomenon to practical use as a technology.

[0004]

[Objectives to be Achieved by the Invention]

As the inventors of the present invention continued to study the crushing impact strength of the cavitation bubbles and the phenomenon of the surface property modification by the cavitation jet, they found that it is necessary to consider not only the physical effects of cavitation such as the crushing impact strength, but also its chemical effects. Furthermore, the inventors of the present invention found that, although cavitation erosion means both cavitation corrosion and cavitation erosion, since they are different morphologies, it is necessary to clearly distinguish a difference between them.

[0005]

As a result of further studies on this matter, the inventors of the present invention found that crushing of the cavitation bubbles not only generates physical effects such as high impact pressures and high-temperature spots, which reach as high as a few thousand degrees,

but also produces electrochemical effects such as generation of an electric potential on the surface where the cavitation bubbles crush. Based on the above described findings and with attempts to prove that the corrosion-erosion resistance of a machine component can be improved by the cavitation jet and to ascertain its mechanism, the inventors of the present invention measured the corrosion speed by using an electrochemical method and analyzed the concentration of hydrogen within the post-crush residual cavitation bubbles. Based on the results of the measurement and analysis, the inventors of the present invention revealed the major factors of the corrosion resistance and the phenomenon of formation of a passive layer as described below.

[0006]

Due to the cavitation jet, the electric potential of the corrosion of carbon steel is high and the anode polarization curve is shifted to the side of the low current density. In other words, if carbon steel is exposed to the cavitation jet, the corrosion speed is decreased and the corrosion-erosion resistance of carbon steel is increased. Since the concentration of oxygen in the cavitation jet has an influence on improvement of the corrosion-erosion resistance, it can be said that the oxidized passive layer has an influence on improvement of the corrosion-erosion resistance. The surface, with which the cavitation jet collides, has a specific environment wherein

the electric potential is low and generates hydrogen. It is clarified that the improvement of the corrosion-erosion resistance by the cavitation jet is affected by the water quality such as the pH value of drinking water. Therefore, it can be said that, when the property of a material surface is modified by using the cavitation jet, mildly alkaline salt is dissolved in liquid so as to prevent the corrosion.

[0007]

Among the above described findings, the inventors of the present invention noted the following knowledge: regarding the control factor for securely reproducing the improvement of the corrosion-erosion resistance of a machine component by the cavitation jet, "in the cavitation erosion, which accompanies cavitation corrosion, if the liquid is acidic, the corrosion by cavitation is significantly increased. By adding an alkali, it is possible to not only prevent the corrosion, but also passivate the cavitation-attacked part." As a result, the present invention was completed.

[0008]

[Means to Achieve the Objectives]

Invention 1 to be patented is a method of corrosion resistant processing a workpiece and/or method of decreasing cavitation erosion on said workpiece, characterized in that, when cavitation bubbles are generated in liquid by using liquid jet or ultrasonic vibrations and collide with a surface of a workpiece and crush, the pH value

of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

[0009]

When the liquid is pure water, the electric potential is low. On the other hand, when the liquid is acidic or alkaline, the electric potential is high. The expression that the electric potential is high means that the electric potential becomes positive as in the case with noble metal. The expression that the electric potential is low means that the electric potential becomes negative. When the electric potential is low, the surface easily becomes ionic and gathers rust. As described above, since improvement of the corrosion-erosion resistance of a material surface by the cavitation jet is done under water by using the chemical effect of cavitation, the water quality significantly affects the outcome. It is found that, in the case where commonly-available water is used, when the electric potential of the material surface is high, iron is corroded according to a Pourbaix curve, but if alkali is added to water, the surface is passivated. Therefore, by adjusting the liquid so that it becomes alkaline, it is possible to prevent corrosion on the surface by cavitation. In other words, in the cavitation erosion, which accompanies corrosion, if the liquid is acidic, corrosion by

cavitation is significantly increased. If the pH value of the liquid is made alkaline, it is possible to not only prevent the corrosion, but also passivate the part which is attacked by cavitation.

[0010]

Invention 2 to be patented is a method of corrosion-erosion resistant processing of a workpiece and/or method of decreasing cavitation erosion on said workpiece, characterized in that cavitation bubbles are generated in alkaline liquid by using liquid jet or ultrasonic vibrations, said cavitation bubbles collide with a surface of a workpiece and crush and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

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[0011]

Invention 3 to be patented is a method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, characterized in that a cavitation processing container containing alkaline liquid is placed on a workpiece, liquid is poured into said container so as to pressurize the inside of said container, pressurizing liquid for generating cavitation bubbles is injected to said pressurized container so as to increase the crushing impact strength of said cavitation bubbles and the electric potential of the surface of said workpiece is

increased thereby forming a passive layer on the surface of said workpiece.

[0012]

Invention 4 to be patented is a method of corrosion-erosion resistant processing of a fluid apparatus and/or a method of decreasing cavitation erosion on said device, characterized in that, when said fluid apparatus has a structure wherein cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations, and a structure wherein said generated cavitation bubbles collide and crush, alkaline liquid is used as said liquid or liquid made by adding an alkaline agent to said liquid is used.

[0013]

Invention 5 to be patented is the method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, as set forth in invention 1, 2, 3 or 4, characterized in that said cavitation erosion means both cavitation corrosion and/or cavitation erosion.

[0014]

Invention 6 to be patented is the method of corrosion-erosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, as set forth in invention 1, 2, 3 or 4, characterized in that said workpiece is made from a material selected from a group made from carbon steel, ferrite group low-alloy

steel, iron group cast metal, stainless steel, aluminum and aluminum alloy.

[0015]

Invention 7 to be patented is a product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance, characterized in that, when cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations and collide with a surface of a workpiece and crush, the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece.

[0016]

Invention 8 to be patented is a product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance, characterized in that, when cavitation bubbles are generated in liquid by using a liquid jet or ultrasonic vibrations and said cavitation bubbles collide with a surface of a workpiece and crush, property modification of the surface of said workpiece, which includes hardening of the surface, improvement of the compressive residual stress and the fatigue stress on the surface, is made by using the peening effect of the crushing impact strength, or when said workpiece is washed by using the crushing impact strength,

the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased thereby generating a passive layer on the surface of said workpiece.

[0017]

Invention 9 to be patented is the product processed to improve corrosion-erosion resistance and/or cavitation-erosion protection performance, as set forth in invention 7 or 8, characterized in that examples of said workpiece include processed products and machine components, which are made from a material selected from a group made from carbon steel, ferrite group low-alloy steel, iron group casting metal, stainless steel, aluminum and aluminum alloy.

[0018]

[Description of the Working Examples]

Next, a device for implementing the present invention and generating a passive layer on the surface of a workpiece will be described based on the drawings. Figure 1 is a schematic diagram illustrating an ASTM-standard cavitation jet device, which is used to prove that the principle and effects of the present invention have practicability. Figure 2 is a schematic diagram illustrating the structure of the cavitation jet effect testing part of the cavitation jet device. Figure 3 is a schematic diagram illustrating a working example of the pressurized cavitation jet device for implementing the present

invention. Figure 4 is a schematic diagram illustrating another working example of the pressurized cavitation jet device for implementing the present invention. Figure 5 is a graph showing the result of measurement of the corrosion electric potential of the cavitation jet at the time of the collision and after the collision. Figure 6 is a Pourbaix curve of an experiment wherein the cavitation jet device of Figure 1 is used.

[0019]

In the cavitation jet device shown in Figure 1, tank 1 wherein liquid jet is stored is connected to cavitation jet effect testing part 2 through liquid supply path 3 and bypass supply path 3a. Plunger pump 4 for pressurizing and feeding the liquid and flowing liquid manometer 5 are placed in the middle of liquid supply path 3. Flow rate regulating valve 6 is placed in the middle of bypass supply path 3a. Cavitation jet effect testing part 2 is connected to tank 1, which stores liquid, through liquid discharge path 7. Thermometer 8, discharging liquid manometer 9 and discharge rate regulating valve 10 are placed in the middle of liquid discharge path 7.

[0020]

In cavitation jet effect testing device 2 shown in Figure 2, high pressure water is injected through the top of nozzle 12. Nozzle 12 is connected to liquid supply path 3 and generates the cavitation jet in measuring room 11, which has a space wherein the cavitation

jet can collide. In Figure 2, 13 represents a corrosion electric potential measuring sensor, which is placed on the surface where the cavitation jet collides. In corrosion electric potential measuring sensor 13, test pieces or material are embedded. Said test pieces and the surface of the sensor, which is exposed to the cavitation jet, are vertically mounted on the jet axis. As the test material, carbon steel S45C is used. As nozzle 12, an ASTM-standard cylindrical nozzle with a diameter of the throat part of 0.4 mm and a length of the throat part of 1.2 mm is used.

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14 represents a liquid collecting pipe, which is made of stainless and fixed to the vicinity of the surface wherein the cavitation jet collides within measuring room 11. Liquid collecting pipe 14 is extended to the inside of liquid storage container 15, which is created on the outside of cavitation jet effect testing device 2, so as to store the collected liquid in liquid storage container 15. Next to liquid storage container 15, salt content storage tank 17 is created and connected to liquid storage container 15 through salt bridge 18. Furthermore, silver chloride electrode 19 is created inside salt content storage tank 17. By using silver chloride electrode 19 as the reference electrode and electric potential measuring device 20, which is placed between sensor 13 and the reference electrode, the

corrosion electric potential is measured. Here, 21 represents a jet shutter, which is created in measuring room 11.

[0021]

Ion-exchange water was used for the test. 0.9 g of calcium carbonate was dissolved into the ion-exchange water and carbon dioxide gas was fed to the water at 0.02 MPa for 25 minutes so that the ion-exchange water became slightly acidic. Also, 60 g of sodium hydrogen carbonate was dissolved into the ion-exchange water so that it became slightly alkaline. The above described slightly acidic and alkaline water were used for the test. To clarify the effects of the pH values of the test water and the water qualities, which were affected by the dissolved ions, the following three types of water were used: (a) ion-exchange water; (2) ion-exchange water wherein calcium carbonate and sodium hydrogen carbonate are dissolved; and (3) ion-exchange water wherein sodium hydrogen carbonate was dissolved. The corrosion electric potential during injection of the cavitation jet and after injection of the cavitation jet was measured by injecting the cavitation jet into the above described water under the conditions: cavitation coefficient α, which it the governing parameter of the cavitation jet, was 0.014, s = 18 mm and cavitation period t - jet = 5 minutes.

[0022]

The corrosion-erosion resistance was evaluated as described below. The corrosion electric potential of each submerged test sample of carbon steel S45C, which was the test material, was measured for 200 seconds after injection of the cavitation jet was stopped in cavitation jet effect testing part 2 shown in Figure 1. Corrosion electric potential EV was displayed by the SHE (standard hydrogen electrode). To evaluate the corrosion-erosion resistance of the test material in the area which was attacked by cavitation jet, sensor 13 was made by embedding a cylindrical carbon steel S45C with a diameter of 6 mm in Teflon (registered trademark), which was an insulating material.

[0023]

As the result of the above described working example, Figure 5 shows the corrosion electric potential after the cavitation jet was injected into each of the test waters and the corrosion electric potential during injection of the cavitation jet. (a) is the highest value followed by (b) and (c). It is believed that such that the types of ions in (b) and (c) were more varied than in (a), (b) and (c) were more affected by the dissolved ions.

[0024]

Table 1 shows the pH value of the test water and the corrosion electric potential immediately before injection of the cavitation jet and during injection of the cavitation jet. Only in the case of (a) was

the corrosion electric potential during injection of the cavitation jet lower than the corrosion electric potential during injection of the cavitation jet. In other words, it is believed that only in the case of ion-exchange water, a peculiar change occurred.

[0025]

[Table 1]

<table>
<tr><td colspan="2"></td><td>(a)</td><td>(b)</td><td>(c)</td></tr>
<tr><td colspan="2">pH</td><td>*</td><td>*</td><td>*</td></tr>
<tr><td rowspan="2">Corrosion electric potential</td><td>Immediately before injection of the cavitation jet</td><td>*</td><td>*</td><td>*</td></tr>
<tr><td>During injection of the cavitation jet</td><td>*</td><td>*</td><td>*</td></tr>
</table>

* The numbers are too small and illegible.

[0026]

In (a) and (c), the surface of the test piece was not corroded after injection of the cavitation jet. However, in (b), after injection of the cavitation jet, the area of the surface, which was attacked by cavitation, was corroded in a ring shape. Therefore, it was found that, depending on the type of the test water used for injecting the cavitation jet, the degree of corrosion-erosion resistance was significantly changed.

[0027]

Based on the above described test results, the conditions wherein the carbon steel generates a passive state from the cavitation jet collision were clarified. In other words, when the cavitation jet is injected, two results are expected: the corrosion-erosion resistance may be improved, or conversely, the corrosion may be promoted. To analyze this significant difference, Figure 6 shows a Pourbaix curve. When the cavitation jet was injected, (a) had an ametabolic condition and (c) had a passive condition. Therefore, no corrosion was observed in the cases of (a) and (c). On the other hand, since (b) had a corrosion-prone condition, the surface was corroded. When there were dissolved ions, the corrosion electric potential of the surface, which was attacked by the cavitation jet, was shifted in the direction wherein the electric potential was increased. Therefore, based on the Pourbaix curve shown in Figure 6, it was found that, by making the test water alkaline, the condition was not the one for the corrosion, but the one for the passive state.

[0028]

In other words, it was found that improvement of the corrosion-erosion resistance by the cavitation jet is affected by the quality of the test water such as the pH value. It was confirmed that, when the surface of a material is modified by the cavitation jet, instead of

using ion-exchange water, alkaline salt, which is inexpensive and harmless, is dissolved in water thereby preventing the corrosion.

[0029]

Figure 3 is a schematic diagram illustrating a working example of the pressurized cavitation jet device. In Figure 3, 22 represents a cavitation processing container wherein workpiece A can be easily put in and out and the surface of workpiece A, which can be sealed by lid 23, can be modified. 24 represents a storage container, which is deeper than cavitation processing container 22, can store cavitation processing container 22 and has a structure wherein stored cavitation processing container 22 is submerged into liquid, which is stored in storage container 24. In cavitation processing container 22, nozzle 25 for injecting cavitation jet B, is connected to supply pipeline for supplying high pressure liquid from pump P. Flow rate regulating valve 27 is placed in the middle of supply pipeline 26. Also, Cavitation processing container 22 has discharge pipeline 28 for discharging fluid from the container to the outside. Discharge pipeline 28 is extended to the outside of storage container 24. Also, discharge pipeline 28 has pressure control valve 29 for controlling the pressure inside cavitation processing container 22. Here, it is possible to create a plurality of nozzles 21 in cavitation processing container 22. Also, it is preferable to place flow rate regulating valve 27 within pipeline

26a, which is bifurcated from supply pipeline 26, instead of directly placing it in supply pipeline 26, which connects high pressure pump P to nozzle 25.

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[0030]

Workpiece A is placed in cavitation processing container 22, which can be easily put in and out and sealed, wherein liquid such as water and oil is filled. Liquid such as water and oil is also filled between cavitation processing container 22 and storage container 24.

[0031]

Flow rate regulating valve 27, pressure control valve 29 and pump P are connected to an electronic control device, which is not shown in the figure, and placed inside cavitation processing container 22. They are controlled by signals from a pressure sensor and a temperature sensor, which are not shown in the figure, so as to produce optimum values.

[0032]

Next, the practical effect (operation) of the above described working example will be described. After workpiece A is placed in cavitation processing container 22, cavitation processing container 22 is sealed by lid 23, which can open and close. Then, high pressure water is injected through nozzle 25 and a cavitation jet is generated so as to make cavitation bubbles B collide with workpiece A. Consequently,

the crushing impact strength of cavitation bubbles B is applied to the surface of workpiece A, which results in hardening of the surface of workpiece A, improvement of the residual stress and improvement of the fatigue stress. Here, by making the state of the liquid, which is filled in cavitation processing container 22 and generates the cavitation jet, alkaline, the electric potential of iron or workpiece A containing iron is increased and passivated. To change the state of the liquid alkaline, alkaline liquid is used as the above described liquid from the beginning, or baking soda, lime or another alkaline agent may be added to the above described liquid so that it becomes alkaline. Here, if the state of the above described liquid is made acidic, the electric potential of iron or workpiece A containing iron is increased. However, in this case, iron or workpiece A containing iron is corroded.

[0033]

To increase the crushing impact strength of cavitation bubbles B, the flow rate of the pressurized water, which is fed to cavitation processing container 22 through nozzle 25, is controlled by flow rate regulating valve 27. Also, the flow rate of the pressurized water, which is discharged from cavitation processing container 22, is controlled by pressure control valve 29. By controlling each flow rate, the pressure of the liquid inside cavitation processing container 22 is controlled.

[0034]

Furthermore, if cavitation processing container 22 has a gas-phase part, the gas-phase part is compressed by the pressurized water. Therefore, to pressurize cavitation processing container 22, it takes a certain period. To solve this problem, according to the present working example, the depth of storage container 24 is increased so as to pressurize cavitation processing container 22 in a short period, and, by using the pressure of the liquid, which is filled in storage container 24, a predetermined pressure is applied to cavitation processing container 22. As a result, it is possible to pressurize the inside of cavitation processing container 22 and decrease the gas-phase part in cavitation processing container 22 in a short period.

[0035]

As described above, compared with the case wherein cavitation processing container 22 is not pressurized, according to the present working example, it is possible to significantly improve the residual stress, improve the fatigue strength, apply the compressive residual stress from the processing surface deep into the inside and increase the corrosion-erosion resistance. Furthermore, compared with the case wherein cavitation processing container 22 is not pressurized, it is possible to increase the corrosion-erosion resistance of the surface of a workpiece by using the short-time treatment.

[0036]

Figure 4 is a schematic diagram illustrating another working example of the cavitation jet device. According to the second working example, the depth of storage container 24 is decreased relative to the depth of cavitation processing container 22, and liquid runs off from the upper edge of cavitation processing container 22. The processing effect is the same as that of the first working example. According to the second working example, it is also necessary to pressurize the inside of cavitation processing container 22, cavitation processing container 22 is sealed by lid 23 and liquid spills the gap between lid 23 and the upper edge of cavitation processing container 22. Here, by placing a weight on top of lid 23 of cavitation processing container 22 or connecting the lid to the container by a spring having a predetermined spring constant, it is possible to mechanically pressurize the inside of cavitation processing container 22. Naturally, it is possible to control the pressurizing force by an electronic control device and the like.

[0037]

[Effects of the Invention]

As described above in detail, the present invention is a method of corrosion resistant processing of a workpiece and/or a method of decreasing cavitation erosion on said workpiece, characterized in that, when cavitation bubbles are generated in liquid by using liquid

jet or ultrasonic vibrations and collide with a surface of a workpiece and crush, the pH value of said liquid is adjusted so that the liquid becomes alkaline and the electric potential of the surface of said workpiece is increased by said crushing of the cavitation bubbles thereby forming a passive layer on the surface of said workpiece. Also, the present invention is a product processed to improve corrosion-erosion resistance and/or cavitaion-erosion protection performance, which has the above described characteristic.

[0038]

As described above, in the case wherein the surface of a material is modified by collision of the cavitation jet, only by adjusting the pH value of liquid so that the liquid becomes alkaline and increasing the electric potential of the surface of the workpiece, it is possible to not only prevent the corrosion of the surface of said material, but also passivate the part wherein the cavitation jet collides thereby improving the corrosion resistance and decreasing the cavitation erosion.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a schematic diagram illustrating an ASTM-standard cavitation jet device, which is used to prove that the principle and effects of the present invention have practicability.

[Figure 2]

Figure 2 is a schematic diagram illustrating the cavitation jet effect testing part of the above described ASTM-standard cavitation jet device.

[Figure 3]

Figure 3 is a schematic diagram illustrating a working example of the pressurized cavitation jet device for implementing the present invention.

[Figure 4]

Figure 4 is a schematic diagram illustrating another working example of the pressurized cavitation jet device for implementing the present invention.

[Figure 5]

Figure 5 is a graph showing the result of measurement of the corrosion electric potential of the cavitation jet at the time of the collision and after the collision.

[Figure 6]

Figure 6 is a Pourbaix curve of an experiment wherein the cavitation jet device of Figure 1 is used.

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[Explanation of the Codes]

1: tank

2: cavitation jet effect testing part

3: liquid supply path

3a: bypass liquid supply path

4: plunger pump

5: flowing liquid manometer

6: flow rate regulating valve

7: liquid discharge path

8: thermometer

9: discharging liquid manometer

10: discharge rate regulating valve

11: measuring room

12: nozzle

13: corrosion electric potential measuring sensor

14: liquid collecting pipe

15: liquid storage container

16: path

17: salt content storage tank

18: salt bridge

19: silver chloride electrode

20: electric potential measuring device

21: jet shutter

22: cavitation processing container

23: lid

24: storage container

25: nozzle

26: supply pipeline

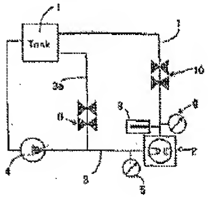
26a: pipeline

27: flow rate regulating valve

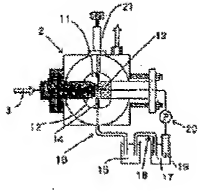
28: discharge pipeline

29: pressure control valve

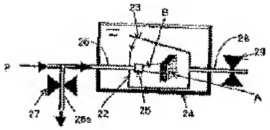
[Figure 1]



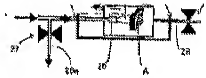
[Figure 2]



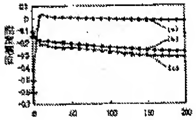
[Figure 3]



[Figure 4]



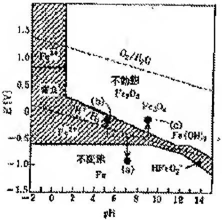
[Figure 5]



(x-coordinate)

Corrosion electric potential

[Figure 6]



(upper blank area)

Passive state

(shaded area)

Corroded area

(lower blank area)

Ametabolic area